Choosing the Right Frequency for Your Wireless Timekeeping Solution

What You Need to Know

The Situation

Synchronized time keeps people and processes organized, improving efficiency in virtually any environment. For schools and colleges, accurate clocks keep classes, sports activities, and other events on schedule and coordinated with bells. In healthcare organizations, accurate systemwide synchronized time is necessary to retain accreditation for specific procedures and to record the time of life and death events. Manufacturing companies rely on synchronized time to maintain daily schedules and processes, directly impacting cost efficiencies. Nearly every industry and business can benefit from cost and labor efficiencies when clocks throughout the organization are in sync.

The importance of time synchronization has driven the evolution of the technology, allowing facilities to deploy clock systems faster and more cost-effectively and efficiently than ever before. Over the last 20 years, a breed of proprietary wireless systems has emerged, eliminating the need to pull wires throughout a building for a wired master clock system or to depend on the weak signal strength of atomic time (WWVB) broadcasts from Fort Collins, Colorado. Most new wireless systems utilize similar design concepts that include local transmission of a highly accurate time signal and wireless clock receivers. However, the wireless frequencies used by the various system manufacturers differ greatly, directly impacting performance. Choosing the right frequency is essential to avoid synchronization failure, a congested wireless spectrum, interference with other technologies, or the need for additional costly infrastructure modifications.

Traditional Time Synchronization Technologies

Wired Master Clock Systems

Wired master clock systems have been used to deliver synchronized time for more than 60 years. The technology was developed in the 1940s and eventually became widely adopted by schools, hospitals, and manufacturing companies. Wired master clock systems have been most commonly added during the construction of new buildings due to the need to pull wiring to each location a clock might be hung. A wired system features a master clock that sends electrical pulses to each individual clock to synchronize and set the time. While wired master systems were a major breakthrough when introduced, costly, time-consuming repairs eventually occur when wires degrade over time or are accidentally cut (requiring subsequent efforts to locate the problem deep within walls). Additionally, expanding the system to synchronize clocks in new rooms, building additions, or renovations can create a myriad of problems, especially with an aging system.

Atomic Time

The advent of atomic time in the 1950s made highly accurate synchronous timekeeping more accessible. Today, Cesium atomic time is considered the international standard for timekeeping technology in the world. The atomic time in North America is most popularly known as the National Institutes of Standards and Technology (NIST) time signal that emanates from the WWVB radio station in Fort Collins, Colorado. The signal is sent from the WWVB atomic clock to a 23-kW transmitter broadcasting at a low 60 kHz frequency to deliver Coordinated Universal Time (UTC) long distances. The signal is powerful enough to cover most of the continental United States and well into Canada.

While the WWVB signal can be received and used to synchronize clocks at great distances from the source, it is susceptible to interference from other radio signals, and it has difficulty penetrating common commercial building materials, such as concrete and metal. The signal is also affected by ground moisture and atmospheric conditions. As a result, clocks will often drift, compromising the reliability of the synchronization. The shortcomings of atomic time synchronization in commercial environments have driven the development of locally transmitted wireless time synchronization solutions.

Wireless Time Synchronization (Locally Transmitted)

In the early 2000s, the introduction of a locally broadcast wireless radio signal to synchronize clocks was a welcome innovation in timekeeping technology for commercial and industrial applications. Local wireless systems include a time source that provides the signal to a transmitter, which then broadcasts the time signal to all the clocks, timers, bell controllers, and other wireless timekeeping devices throughout a facility. A locally transmitted wireless time synchronization system provides an optimal level of signal strength to cover an entire facility campus, allowing placement of clocks virtually anywhere within transmission range.

Local wireless systems typically include three basic components:

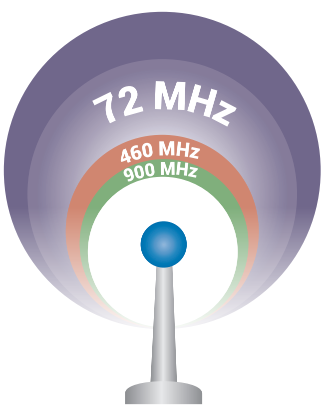
1. A highly accurate time source such as a GPS satellite receiver or a Network Time Protocol (NTP) server
2. A local transmitter
3. Clocks equipped with wireless receivers

When using a GPS receiver, time is obtained from a network of 24 orbiting satellites, each with Cesium 133 atomic time generators aboard. When using an NTP server, an authoritative time source — such as the NIST signal — is accessed via the internet. Both time sources can provide the correct time to the transmitter, which acts as a wireless master clock and distributes the signal throughout the facility to be received by the wireless clocks.

Wireless time synchronization systems essentially take care of themselves. They are usually unaffected by power outages since analog clocks run on batteries, and digital clocks are able to maintain an internal real-time clock (RTC) until power is restored. Built-in daylight saving time (DST) calendars are kept within the transmitter or the clocks and automatically adjust the clocks at the start and end of DST each year. Most importantly, a locally transmitted wireless system allows clocks to be placed anywhere within the signal range without tethering to wires or requiring structural accommodations. Building additions, renovations, or changing facility needs can be easily accommodated.

SIGNAL COVERAGE RANGE

Using just 1 watt of transmission power in a 50,000 square foot building, the 72 MHz frequency delivers the time synchronization signal throughout the entire building, where the other frequencies cover only a fraction of the space.*



72 MHz at 1 Watt = 50,000 sq. ft. coverage

460 MHz at 1 Watt = 10 sq. ft. coverage

900 MHz at 1 Watt = 5 sq. ft. coverage

**Based on a specific test of all three frequencies under identical building conditions.*

All Wireless Clock Systems Are Not Created Equal

When making the move to a locally transmitted wireless time synchronization system, it's important to understand variations in the available systems. While today's systems all essentially work in the same way, different systems use different radio frequencies to transmit the local signal, and each frequency has unique transmission characteristics. In addition, wireless technology has been introduced into a wide range of products that also use a variety of radio transmission frequencies, leading to greater potential for signal interference. Finally, the type of building construction, the distance the signal must cover, and the range of wireless technologies in use in the facility must be considered when selecting a synchronized timekeeping solution.

Wireless Clock Synchronization System Frequencies

There are three radio frequencies used by different wireless systems to transmit the synchronization signal to the clocks:

1. **72 MHz** – This frequency proves to be an excellent solution for transmitters and clocks, as it provides an outstanding balance between transmission power (signal penetration) and efficiency. Plus, 72 MHz is not used by many other technologies, so congestion is not a concern.

2. **460-470 MHz –** This frequency range is fairly congested and used by many two-way radios, certain television channels, pagers, and essential medical telemetry systems, making it unsuitable for time synchronization in most institutions, especially healthcare.

3. **900 MHz –** This frequency is different from the other two in that each clock functions as both a transmitter and a receiver creating a small web of signal coverage. The time signal repeats from clock to clock within range of each other to create a network of the signal throughout a modest facility. A 900 MHz system is typically inefficient in providing adequate signal to cover long hallways or multiple buildings

Signal Strength and Range

Each frequency requires different output power and characteristics to ensure the signal is received by the clocks:

1. **72 MHz –** As little as 1 watt of power can effectively transmit the 72 MHz frequency signal throughout buildings of up to 100,000 square feet. For larger installations, a transmitter configured with an external roof-mounted antenna on a centrally located building will use output power levels of just 5 to 30 watts to deliver the signal to clocks across an entire hospital or university campus.

2. **460-470 MHz –** The power required to drive the signal at 460 MHz across a large building or campus is typically very high, ranging from 50 to 100 watts. That's five times as much power as a 72 MHz system. The FCC has imposed strict power limitations on 460 MHz systems in many large urban areas since the powerful signal can spill over and cause interference in nearby residential areas using radio-based products in the same frequency range.

3. **900 MHz –** The 900 MHz system works best for smaller, more confined installations. Because the FCC limits the output power to 1 watt, a 900 MHz system for a larger installation or a campus with distributed buildings could very well require multiple subsystems deployed within each building. This approach may often require additional setup by maintenance staff and the ongoing management of infrastructure hardware.

Signal Interference

The potential for interference and disruption in the signal delivery is a major consideration when choosing a system:

1. **72 MHz** – Unlike the higher, more congested frequencies, the 72 MHz band is used by only a very small volume of technologies, reducing the chance of signal interference. More importantly, the 72 MHz frequency is tightly regulated by the FCC, significantly limiting the potential of interference from other products within an organization or surrounding neighborhood. The FCC authorizes each and every 72 MHz installation as the primary licensee and primary user for the specified channel in the 72 MHz band. If interference were to occur in the future, the holder of the primary license takes priority over any secondary or unlicensed users. At the 72 MHz frequency, there are also 49 channels that can be licensed. If other users pop up in the vicinity, they can be easily spread out to eliminate potential interference.

2. **460-470 MHz** – Like a 72 MHz system, a 460 MHz system requires an FCC license. Unfortunately, the frequency is so heavily shared in many areas of the country that there are actually few, if any, 460 MHz licenses still available. Police, taxicabs, tow trucks, and other services also operate at 460 MHz. The popularity of the 460 MHz frequency also increases the possibility of signal interference. In fact, many hospitals are trying to abandon this frequency for telemetry systems due to the congestion in the range. Adding a time synchronization system using the 460 MHz frequency increases the radio frequency noise and risk of interference and disruptions to telemetry within the facility.

3. **900 MHz** – The FCC does not license the 900 MHz frequency, which makes the 900 MHz frequency appealing to the manufacturers of numerous products. But, like the 460 MHz frequency, the 900 MHz frequency is used by a wide range of products, such as closed-circuit television (CCTV), cordless telephones, microphones, two-way radios, intercom systems (building automation), and more. The popularity of the frequency greatly increases the potential for signal interference and resulting time drifts, which can be significant problems. The FCC license required at other frequencies helps to control the products that can operate in the same vicinity, minimizing signal interference.

Signal Penetration

No matter how powerful the system or how little interference is encountered, the synchronization signal must be able to penetrate through building walls or other obstructions to reach the clocks:

1. **72 MHz** – The wavelength of the 72 MHz frequency is well-documented to effectively penetrate through thicker exterior walls and common commercial building materials, such as stone, metal, concrete, and brick. In addition, atmospheric conditions — particularly moisture — have little effect on the signal. These strong signal penetration characteristics allow a 72 MHz system to use significantly lower levels of output power to easily deliver the signal throughout buildings of many sizes or across an entire university or healthcare campus.

2. **460-470 MHz** – In general, the higher the frequency, the greater potential for problems with signal penetration. A signal distributed at the 460 MHz frequency is less reliable than a 72 MHz signal and may be reflected by thick walls or certain construction materials like metal or concrete.

3. **900 MHz** – Systems using the 900 MHz frequency take another leap in the potential for blocked signals due to building construction. Since these systems use the clocks within range of each other to form connections and pass the time signal, interior construction materials or other building features can cause a break in the signal. Even moisture on a brick wall can interfere with the signal.

Expansion Potential

One of the primary advantages of a locally transmitted wireless system is the ease of expansion when new construction or remodeling cause clocks to be relocated or added to the system:

1. **72 MHz** – The lower required output power and effective signal penetration of the 72 MHz frequency allow greater expansion capability than other systems. As the system grows, the output power can be increased minimally to cover greater distances to synchronize the new clocks.

2. **460-470 MHz** – While a 460 MHz system can be expanded without additional infrastructure, the severe FCC restrictions on the output power could be a limiting factor. It may not be an option to increase the signal strength to reach new buildings or be able to penetrate the new construction materials.

3. **900 MHz** – Building infrastructure and signal requirements of the 900 MHz system dictate where a clock may or may not be placed to maintain the communication web within the facility. When a 900 MHz system grows too large, or clocks are too spread out, repeaters must be used to maintain a strong connection throughout your network. The additional hardware infrastructure can be cumbersome and costly in larger facilities or campuses with multiple buildings.

Determine Your Requirements First

To find the right wireless timekeeping solution, you must start by understanding the current needs of your organization. Furthermore, knowing how the facility may evolve over time due to growth, renovation, new construction, or other structural projects will help you select the technology that will work best for your needs.

The timekeeping technology should incorporate a wireless frequency seldom impacted by other wireless products. In addition, a frequency protected by FCC licensing — ISED licensing in Canada — provides greater peace of mind that your system will continue to be shielded from potential interference now and in the future. Signal efficiency, power output flexibility, and penetration characteristics are all important factors in a high-performance system.

Taking the time to understand the characteristics of the different transmission frequencies and how they may work within your environment is the best way to ensure your system will keep your organization in sync for many years to come.